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The Relative Feeding Value of Ground Soybeans and Soybean Oilmeal for Milk and Butterfat Production By The Dairy Cow

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THE RELATIVE FEEDING VALUE OF GROUND SOYBEANS AND SOYBEAN OILMEAL FOR MILK AND BUTTERFAT PRODUCTION BY THE DAIRY COW

by

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INTRODUCTION

The development of the soybean to a crop of great importance the past few years has been more rapid, perhaps, than that of any other plant. Most particularly is this true of its rise in the United States.

Figures from the U. S. Yearbook (1) show that in 1917 there were only 460,000 acres of this crop planted for all purposes, this, however, representing a 50% increase over 1916. In 1924, 2,566,000 acres were planted for all purposes, and 1925 figures show a still greater increase of 25%. The acreage for seed production alone increased from 168,000 acres in 1919 to 452,000 acres in 1925 with an average of 262 acres for the five-year period. There were 3,817,800 bushels of seed harvested per year for the five-year period or an average of 14.5 bushel per acre.

The plant was grown originally in Eastern Asia, probably in Korea, where it was an important food crop, fully 5,000 years ago. In value, extent and variety of uses it is the most important legume grain in the Asiatic Countries. In China and Japan, it is second only to rice as an important food crop. There it is utilized in a great variety of products, and when eaten with rice makes a well balanced diet. Some of its uses are as dried beans, green beans, in the making of soybean milk, soybean cheese, soy sauce and bean sprouts. Other uses that has been developed for the bean and its products are in the making of soap, butter and lard substitutes, in

the manufacture of paints, varnishes, linoleum, explosives, soybean flour which may be used in bread, muffins, biscuits and pastries, and finally, as a stock feed and a fertilizer. In fact, on account of the rapid improvement in the process of refining the oil, there seems to be no use to which oil is put in the manufacture of foodstuffs in which soybean oil may not be employed. Because of the low starch content of the flour, it is especially adaptable to the feeding of invalids (2).

By a process of extraction, we have available for use a residue known as soybean cake. This cake is ground into a fine meal, and in this form has proven equal to the excellent feed, linseed oil meal, for milk production and even slightly superior for fat production. The ground soybeans when fed to cattle were found to be superior to both soybeanoilmeal and linseed oilmeal for milk production.

Various stations have conducted experiments for the purpose of determining the value of soybeans and soybean oilmeal. A review of the results obtained will be interesting in this connection.

Fairchild and Wilbur (3) found that soybean oilmeal was practically identical in value to linseed oil meal for milk production, but that ground soybeans were superior to both soybean oilmeal and linseed oilmeal for fat production. It would seem that even though containing a lower amount of protein than the soybean oilmeal, the additional fat in the ground beans gave them a higher feeding value than that of the oilmeals.

McCandlish (4) reported a 6% decrease in milk production accompanied by an 8% increase in fat yield when ground soybeans were fed in the ration as against linseed oilmeal.

McCandlish (5) found that soybean oilmeal, old process linseed oilmeal, peanut meal and gluten feed were of approximately equal value as a protein supplement. For palatability soybean oilmeal is second only to linseed oilmeal.

Haldaway (6) returns the following results from a series of experiments. He distinguishes between the gross resorbed protein and the digestible protein in a feed by deducting from the latter that used for other "avenues of utilization"; namely, maintenance protein, metabolic feces protein, and body gain and losses. On the basis of the former method, he ranks the three feeds in the order of their efficiencies.

Peanut meal	29.6%
Soybean meal	27.9%
Cottonseed meal	27.8%

By the latter method, the peanut meal still retained the advantage but the latter two exchangedpositions:

Peanut meal	50.0%
Cottonseed meal	46.0%
Soybean meal	45.0%

The reversal of the results in the second trial was accounted for by the higher digestibility of the soybean meal protein which in turn was due to the high plane of protein entake. Had the

feeds beenon the same planes the values of the two feeds would have been practically identical.

Price (7) compared grown soybeans with cottonseed meal with a basal ration of corn and cobmeal and obtained the results shown below:

Ground soybeans	14.4	pounds of milk
	.81	" " fat
Cottonseed meal	13.6	" " milk
	.77	" " fat

Cook (8) states that cottonseed meal returned .0014% more milk, while soybean oilmeal returned .038% more fat when fed with a basal ration of corn and cobmeal, dried beet pulp, silage, soilage, and hay.

The general conclusion that may be drawn fromthese studies is that when soybeans or soybean oilmeal furnish the experimental protein supplement, there is a slight increase in the percent test and total fat production accompanied by a noticeable decrease in total milk production.

PLAN OF EXPERIMENT

It is the purpose of this experiment to compare directly, one with the other by the reversal method, ground soybeans and soybean oilmeal to determine their relative value as a protein supplement for milk and fat production.

The experiment extended over a period of 120 days and was divided into three periodsof 40 days each beginning November 21, 1925

and continuing to March 31, 1926 inclusive. Each 40-day period was further divided into four 10-day sub periods, the first 10 days of each period being used as a transition period, and only the data of the succeeding 30 days being used in the calculations. Seven animals were used in the experiment, these being grouped into two lots of as great uniformity as possible. Three animals were placed in Lot I and four in Lot II. Table I gives the description of the animals, the group to which they belong, etc.

TABLE I

Description of animals

No.	Breed	Age	Weight	Lactation period	Stage in Lactation	Stage in Gestation
Group I		Yr. Mo.	#s	1st.2nd.etc	days	days
324	Hol.	2 - 8	1105	1	90	open
306	Hol.	4 -11	1405	2	108	41
261	Guer.	2 -11	1001	1	149	open
Group II						
24	Hol.	10 -11	1550	8	67	15
82	Jer.	6 -11	1050	4	201	57
323	Hol.	2 -10	1300	1	66	open
158	Grade Jer.	6 - 2	1100	4	212	32

The animals were kept in stanchionsin a separate barn and were allowed exercise in a dry lot for a short time each day at such times as the weather permitted. They were weighed at the same hour each day for three consecutive days of each 1-day period and the average of these weights taken as the weight for that period. They were well cared for at all times being given similar treatment to that

accorded animals onofficial test. They were milked twice each day with the mechanical milkerand records kept of the milk production. Ten-day composite samples were taken and tested at the conclusion of each 10-day period.

Feeds, feeding and rations

The feeds used in this experiment were of good quality on the whole and compared very favorably with the all analysis given by Henry and Morrison as shown by the data tiven in Table II. In all instances the top series of figures is the analysis of the experimental feed, and the lower series of figures is the analysis as given by Henry and Morrison.

TABLE II

Analysis of Feed.

Feed	water	ash	cr. prot.	fiber	N.F.E.	Fat
alfalfa	13.6	5.99	15.93	29.86	33.56	1.06
hay	8.6	8.60	14.9	28.30	37.3	2.3
	80.32	1.28	2.25	5.15	10.54	.46
silage	73.79	1.70	2.10	6.30	15.40	.80
	11.62	1.14	10.67	2.44	71.09	3.04
corn	10.50	1.50	10.10	2.00	70.90	5.00
	11.13	6.61	14.35	12.29	50.83	4.79
bran	10.10	6.30	16.00	9.50	53.70	4.40
	10.01	2.84	13.65	10.28	58.86	4.36
oats	9.20	3.50	12.40	10.90	59.60	4.40
	7.96	4.82	36.42	8.51	24.70	17.59
Soybeans	9.90	5.30	36.50	4.30	26.50	17.50
soybean	8.57	6.06	40.25	5.42	33.68	6.02
oilmeal	10.50	4.90	43.20	5.30	29.50	6.60

The alfalfa hay was grownon the station farm and wasfrom the 1924 crop. It was of good quality with the exception of occasional coarseness of stems.

The silage was good being high in protein content and low in crude fiber. It was onsiled from the 1925 crop grown on the station farm. The fat content was ather low due primarily to the fact that corn was rather too immature at the time of cutting.

The corn, oats and bran were all secured from the local elevator and were locally grown. The corn was about 2% low in fat content, however, while the bran was somewhat high in crude fiber. On the average, tho, the analysis checks very closely with Henry and Morrison.

The ground soybeans and the beans for the soybean oilmeal were all produced within Brookings or in adjoining counties. Their analysis compared very favorably with the average, the greatest variation occurring in the crude fiber which was about 50% higher than the all-analysis, and in the crude protein in the oilmeal which was 3% too low.

The grain feeds were kept in separate compartments and each animal's feed was weighed out individually at the time of feeding. All animals were fed twice daily, grain, hay and silage being given each, and all feeds weighed out accurately. The silage was placed in the feed box and the dry grain placed on top of this. The hay was given after the grain feed had been consumed. All feeds were given at the time of or immediately following the milkering process.

The rations given the animals were theoretically balanced for each individual animal, the chemical analysis of the feeds as determined by the station chemist being used in the calculations, and the Modified-Wolff Lehman standard used for determining the requirements. The rations werecalculated at the beginning of each 40-day period and such corrections made as were necessary. The basal ration of alfalfa hay,

silage, corn, bran and oats were used in all experiments, however, it was varied according to the needs of the particular animal as was the experimental feed.

TABLE III

Rations fed in the several periods

Group	Period I	Period II	Period III
I	Basal Ration: alfalfa hay : silage, corn, bran - oats : plus ground soybeans	Basal ration plus soybean oilmeal	Basal ration plus Ground soybeans
II	Basal Ration plus Soubean Oilmeal	Basal ration plus Ground soybeans	Basal ration plus Soybean oilmeal

In the calculations the average was taken of the first and third periods in each group and balanced against the middle group. It was thus possible to secure very close and accurate results in the experiment.

Water and salt were before the animals at all times.

DIGESTION TRIALS

Two five-day digestion trials were run during the course of the experiment, the first in the last five days of the first thirty-day period, and the second in the five days immediately following the

third thirty-day period. Results were thus obtained from both the bean and the meal periods from which to obtain the digestion coefficients.

DISCUSSION OF RESULTS

Weights of the animals

Throughout the following discussion the period in which the soybean oilmeal was fed will be referred to as the "meal" period, and that in which the ground soybeans were fed will be designated as the "bean" period in order to obtain simplicity of expression.

The average weights of the animals in each period are presented below.

No. of animal	306	324	261	24	323	82	158
Av. of 1st and 3d periods	1475	1127	1044	1541	1384	1042	1151
Av. of 2d period	1476	1118	1028	1547	1385	1028	1137

Average of all animals for 1st and 3rd periods (bean period) 1152.6

Average of all animals for 2nd period (meal period) 1255.2

Only a very small difference is found to exist between the weights of the animals during the trial. In four instances the averages for the individual animals favors the bean period to a slight extent while in the remaining three the advantage is in favor of the meal period. The final average shows an excess weight of 102 pounds in the meal period. By virtue of the higher percent of fat in the bean period, it was to be expected that a greater gain in live weight would be made in this period, however, such was not the case. The most noteworthy point relative to the weights is the gradual, uniform increase in live weight as the period advanced as indicated in Figure I. The heavy black line in the middle graph indicates the plane of increase, the fine line

Showing Live-Weights

Black - Bean period
Red - Meal period

indicating the observed variations. It is noted, also, that all animals made a rather sharp jump the first ten-day period. This may be explained by the fact that they were all taken from the dairy herd where they had been receiving the regular herd ration and placed on the high protein experimental ration.

It may be observed at this point that all animals were in excellent condition of flesh throughout the entire experiment. There was a tendency for them to be somewhat rough coated when first placed on the experiment, however, this condition was soon corrected and the hair became smooth, and the hide much softer and mellow. Animal number 261, a compact typy Guernsey evidenced a little greater tendency to increase in weight as the experiment advanced, however, it did not seem to impair her producing ability for she was the most persistent milker of the lot as will be brought out in a later graph.

No ill effects were noted at any time during the entire experiment. The feeds were apparently very palatable and were eaten quite readily.

The refuse was removed at the end of each two-day period and analysed by the station chemist in order to determine the amount of nutrients refused. On several of these occasions certain of the animals had no refuse at all, an evidence of thepalatability and quality of the feeds given.

Pounds of Feed Consumed

Because of the varied representation of the several breeds and the resultant variation in the size and capacity of the animals, there was naturally a considerable variation in the amount of feed

consumed per animal. Table V presents this data in summarized form.

TABLE V

Pounds of Feed Consumed During the Entire Experiment

No. animal	hay		silage		grain	
	Total	per day	total	per day	total	per day
306	1260	14	3600	40	1380	15
324	1080	12	2700	30	1560	17
261	840	9.3	1800	20	930	10
24	1410	15.6	3600	40	2100	23
323	1257	13.9	2700	30	1612	18
82	1140	12.7	1950	22	1110	12
158	900	10	2100	23	930	10
Averages	1127	12.5	2636	32.5	1374	15.3

Pounds of feed consumed on basis of periods

Total pounds of feed consumed	bean period	meal period
hay	3780	4107
silage	9000	9450
grain	4500	5122
Pounds of feed consumed per day		
hay	12.63	12.44
silage	30.	28.6
grain	15.	15.52
Pounds of hay consumed per 100# live weight	1.1	.99
" " silage " " " " "	2.6	2.27
" " grain " " " " "	1.3	1.24

The animals were on the whole, rather heavy feeders, consuming an average of over 12 pounds of hay, 30 pounds of silage and 15 pounds of grain per day. In proportion to their live weight,

however, the amount consumed was not excessive.

TOTAL NUTRIENTS CONSUMED

Because of the fact that the coefficient of digestibility varies greatly with different animals and with the type of ration fed, it is well to note the relative amount of total nutrients consumed by the several animals before making deductions concerning the digestible nutrients consumed. Table VI shows a summary of the total nutrients consumed by periods.

TABLE VI

Total Nutrients Consumed

Period	Protein	C.F.	N.F.E.	E.E.	T.N.
Bean	1500.75	1801.10	4758.6	365.79	8883.4
Meal	1663.37	1997.18	5675.1	297.61	10008.0
Difference	162.6	196.80	916.5	68.2	1125.0
% dif.	9.7	9.9	16.2	18.6	11.2

There was 11.2% more nutrients consumed in the meal period than in the bean period, even tho the total pounds of fat was much larger in the bean period.

DIGESTION TRIALS

A digestion coefficient may be definbd as a percentage statement of the amount of the digestible protion contained in any particular feed.

The coefficients for each animal as determined in this experiment are tabulated in Table VII. Note must be made of the fact that in these tables the animals are grouped according to periods rather than

according to first and second digestion trials. Hence the coefficients for the animals in Group I for the first digestion trial are shown in the first table together with the coefficients for the animals in Group II for the second digestion trial. All the coefficients for the animals on the bean ration are shown in the first table, while the coefficients for the animals on the meal ration are shown inthe second table.

TABLE VII

Digestion Coefficients

Bean Period # animal	Protein	C.F.	N.F.E.	E.E.	
306	67.1	61.9	86.8	84.3	
324	63.3	61.0	82.0	83.7	
261	67.6	62.4	83.3	84.9	
24	72.0	72.5	90.4	87.4	
323	67.8	73.7	89.8	86.0	
82	67.4	81.1	94.5	88.8	
158	64.5	66.0	87.5	83.3	
averages	65.8	61.9	85.9	85.7	74.8
Meal Period					
306	60.4	72.8	92.8	79.9	
324	67.9	69.9	89.3	82.4	
261	65.0	60.2	88.1	78.8	
24	66.5	49.3	87.8	65.5	
323	67.8	60.7	82.6	80.0	
82	65.1	67.6	81.6	98.8	
158	67.1	67.0	82.8	77.6	
averages	67.	64.9	86.3	80.3	74.6

Characteristic variations are noted in the coefficients with them being slightly higher on the average for the meal period than for the bean period with the exception of the fat coefficient. It is especially noteworthy that altho the fat content was approximately 17.6% greater in the bean period it showed a 6.3% higher coefficient of digestion. It is

ossible that the small amount of fat that is contained in the meal period is in a relatively unavailable form, thus reducing its digestibility. Particularly may this be true of the residual fat in the soybean oilmeal which is not extracted in the processing of the bean.

DIGESTIBLE NUTRIENTS CONSUMED

The coefficients as shown above being used to calculate the digestible nutrients consumed the following results shown in Table VIII were obtained.

TABLE VIII

Total Digestible Nutrients Consumed Per period

Period	protein	C.F.	N.F.E.	E.E.	T.D.N.
Bean	986.78	1115.26	4088.05	290.02	6841.65
Meal	1114.88	1296.69	4898.9	241.97	7855.04
difference	128.10	181.4	810.8	48.05	1013.4
% difference	11.5	14.0	16.6	16.6	12.9

The greatest differences are noted in the N.F.E. and the E.E. The variations in the former may be accounted for by the fact that on account of the relatively low percent of fat in the ration during the meal period it was necessary to increase the amount of corn in order to properly balance the ration. This, of course, increased the N.F.E. proportionately since over 70% of this feed is N.F.E. The increase of fat in the bean period is attributable to the relatively higher fat content of the soybeans.

Contrasting the total digestible nutrients consumed with the total nutrients there is a relatively greater proportion of nutrients digested in the meal period than in the bean period because of the greater

amount of total nutrients consumed in the former period and the greater digestibility of these nutrients for that period, thus resulting in a higher percentage of total digestible nutrients in the meal period.

MILK AND FAT PRODUCTION AND PERCENT TESTS

Figures I, II and III show graphically the production and tests by ten-day periods for the entire experiment.

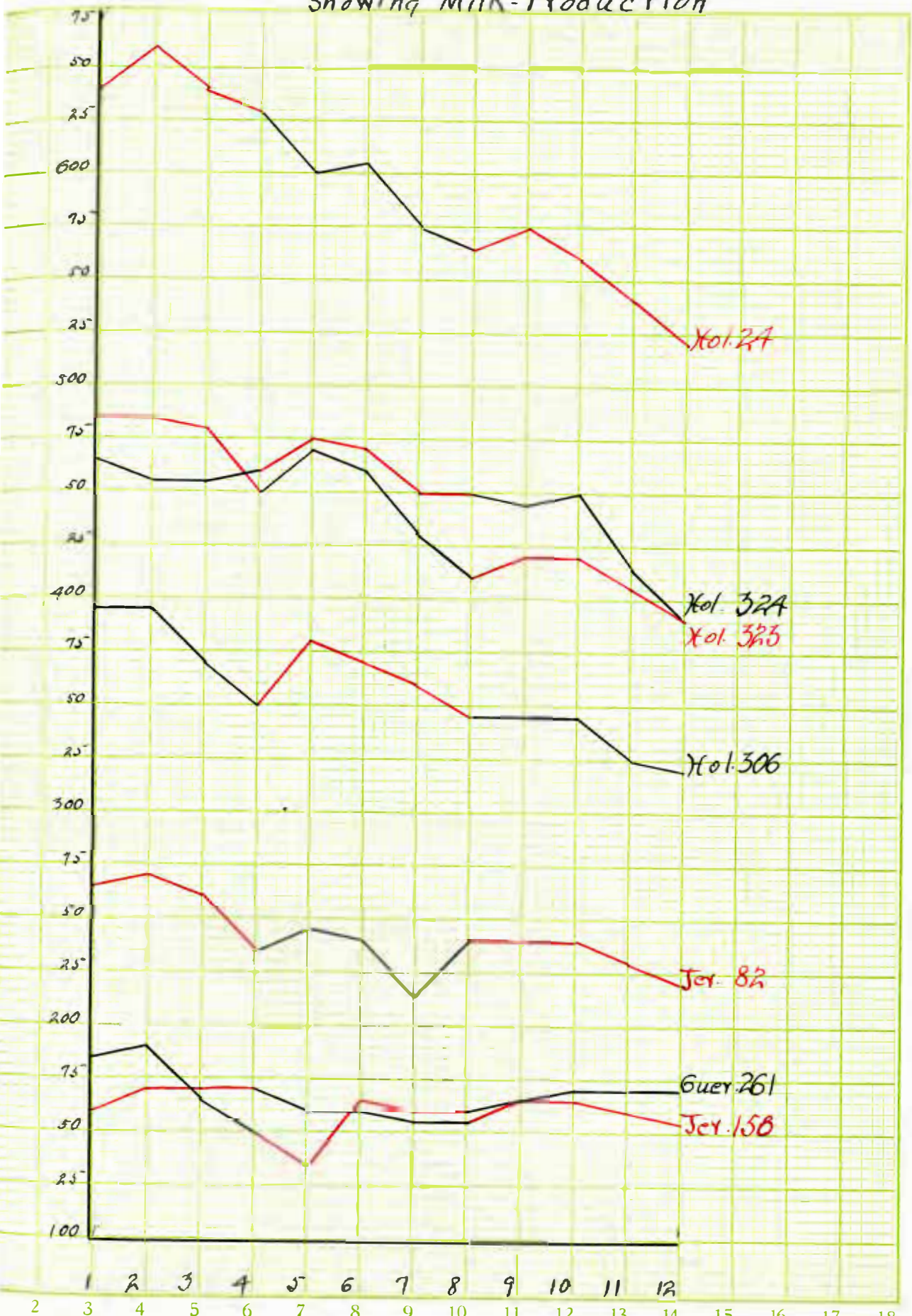
The greatest variation occurs in the pounds of milk produced because of the fact that four of the animals were high producing Holsteins, while the three remaining animals were of the Channel Island Breeds. Greater persistency of flow is found, however, in the latter animals.

Because of the advantage accorded the two Jerseys and the Guernsey in the percent test, the total fat production per animal is much more comparable for all animals. The Holstein, Number 24 still remains at the top due, chiefly, to her much greater production of milk. The other animals are grouped much closer together than was the case in the milk production.

The average test for the four Holsteins was 3.5% while that for the Jerseys and Guernsey was 6.3. The primary point of importance in the percent test graphs is that during the periods in which the soybeans were fed, the percent test averaged 1.69% higher. It may be concluded from this that soybeans in the ration cause, temporarily at least, an increased fat test.

Fig. I.

Showing Milk-Production



Black - Bean period

Meal period - Red.

Red - Meal period

Fig II

Showing Butter Fat Production

W. M. Welch Manufacturing Company, Chicago

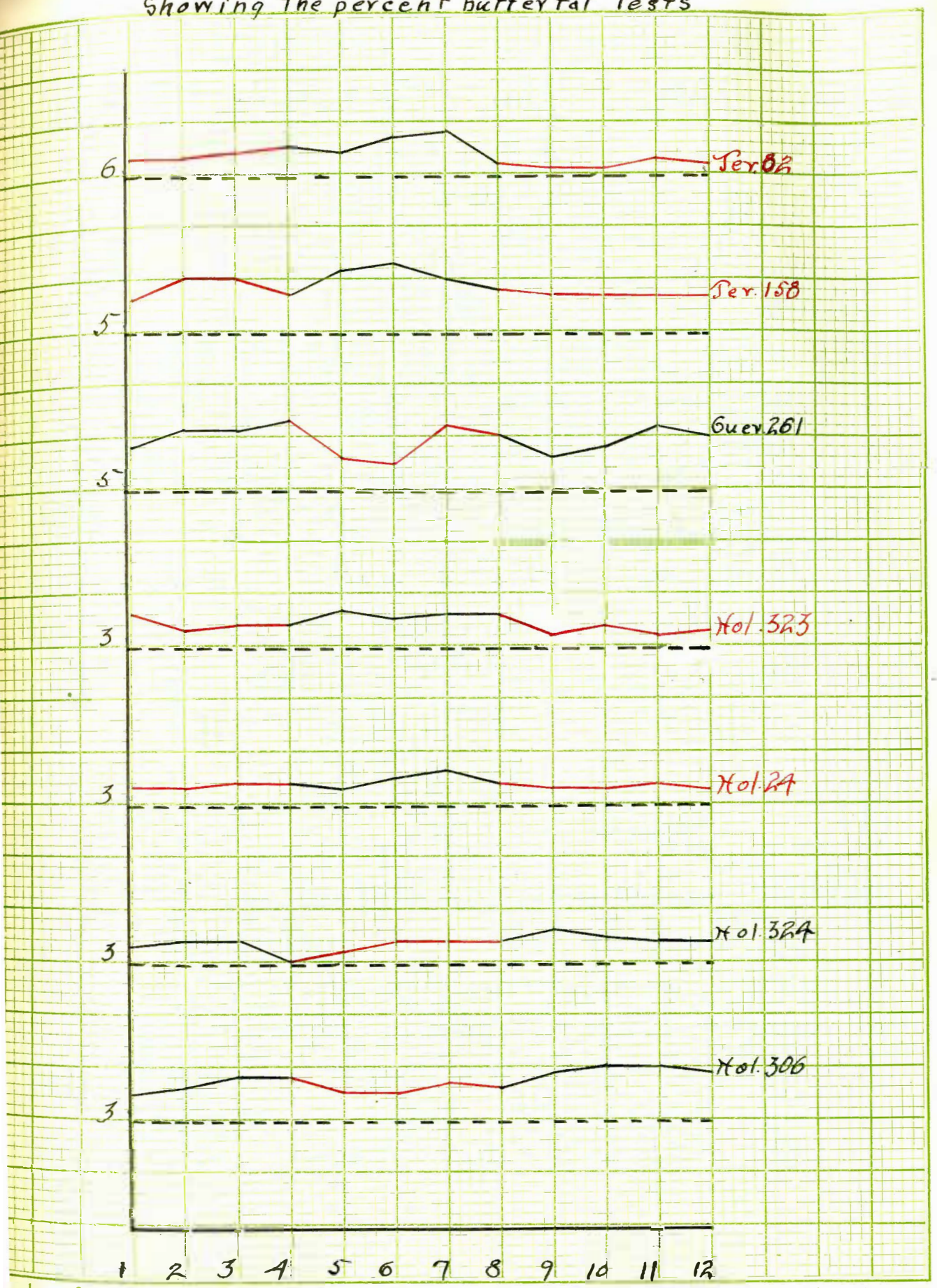
Black - Bean period

Red - Meal period

Red - Meal period

Fig. III

Showing the percent butterfat tests



Black - bean period

Red - meal period

Table IX summarizes the production date by groups by 30-day periods.

TABLE IX

Summary of Production

	1	2	3	total	average	percent increase
MILK						
Bean	3454.5	3287.4	3243.9	9985.8	3328.6	
Meal	3993.7	3844.1	3709.2	11547.0	3849.0	13.5
FAT						
Bean	142.3	137.5	131.6	411.4	137.1	
Meal	160.1	157.2	150.1	467.4	155.8	12.1
% TEST						
Bean	4.12	4.18	4.06	4.12	4.12	1.69
Meal	4.01	4.09	4.05	4.05	4.05	

These figures indicate that there was 13.5% more milk and 12.1% more butter fat produced in the meal period as compared with the bean period, while the bean period excelled in percent test by 1.69%.

SUMMARY

It has been shown that there was a greater consumption of nutrients in the meal period accompanied by a greater total production of milk and fat, regardless of the fact that the percent test was somewhat higher in the bean period. Because of the fact that these two factors tend to offset each other, further calculation must be made in order to determine the relative value of the two. Furthermore, because of the fact that there were four animals in one group and only three in the other, there are more "cow-days" in the former group. This causes a discrepancy which must be corrected. In order to do this all calculations were reduced to a cow-day basis by dividing through by 300 in the bean

period and 330 in the meal period, the total number of cow-days in the respective periods. These results were then multiplied by 90, the total number of days in the experiment, thus reducing everything to a cow basis per period.

Such calculations were made, and the data thus obtained, with conclusions, is summarized in the Tables X, XI, XII and XIII.

TABLE X

SUMMARY OF PRODUCTION AND NUTRIENTS CONSUMED

	bean period			meal period		
	HAY	SILAGE	GRAIN	HAY	SILAGE	GRAIN
Pounds of feed consumed	1134	2700	1350	1119.6	2506.6	1552.1
	PROT.	FAT	T.N.	PROT.	FAT	T.N.
Total Nutrients Consumed	450.2	109.7	2665.0	453.6	81.16	2729.6
Total Digestible Nutrients Consumed	296.0	97.8	2052.5	313.3	65.99	2380.3
	PER DAY	PER PERIOD		PER DAY	PER PERIOD	
Total milk production	33.28	2995.2		34.99	3149.1	
Total fat production	1.37	123.3		1.42	127.8	

TABLE XI

RELATIVE EFFICIENCY OF PRODUCTION

Pounds of feed required to produce 100# of milk and 1# of fat

	hay	silage	grain	hay	silage	grain
100# of milk	37.88	90.145	45.07	35.59	81.314	49.29
1# of fat	9.20	21.90	10.95	8.76	20.04	12.14

Pounds of milk and fat produced per pound of total nutrients consumed

	prot.	fat	T.N.	prot.	fat	T.N.
Pounds of milk	6.65	27.30	1.124	6.96	38.8	1.154
Pounds of fat	.274	1.12	.046	.282	1.58	.0468

Pounds of milk and fat produced per pound of total digestible nutrients consumed

	prot.	fat	T.D.N.	prot.	fat	T.D.N.
Pounds of milk	10.118	30.63	1.459	10.05	47.7	1.32
Pounds of fat	.417	1.26	.06	.408	1.937	.054

TABLE XII

RELATIVE EFFICIENCY OF THE EXPERIMENTAL FEEDS

Pounds of feed required to produce 100# milk and 1# fat

	beans	oilmeal
100# of milk	45.08	49.30
1# of fat	10.95	12.15

Pounds of milk and fat produced per pound of experimental feed consumed

	beans	oilmeal
Pounds of milk	2.2178	2.0284
Pounds of fat	.0913	.0823

Pounds of milk and fat produced per pound of total digestible nutrients consumed

	prot.	fat	T.D.N.	prot.	fat	T.D.N.
Pounds of milk	10.118	29.6	1.455	10.050	47.6	1.323
Pounds of fat	.415	1.26	.0598	.408	1.94	.0537

TABLE XIII

SUMMARY OF EFFICIENCY OF PRODUCTION EXPRESSED IN PERCENTAGES

	BEAN %	MEAL %
Pounds of feed to produce 100# milk	8.9	0
" " " " " 1# fat	9.8	0
Pounds of milk produced per pound of T.D.N. cons.	9.0	0
" " fat " " " " " " " "	10.6	0
Pounds of experimental feed to produce 100# milk	8.5	0
" " " " " " " 1# fat	9.9	
Pounds of milk produced per # of T.D.N. in exp. feed	9.1	0
" " fat " " " " " " " "	10.16	

It is noted from this series of summaries that there are more pounds of feed, total nutrients and total digestible nutrients consumed per animal for the period in the meal period than in the bean period. Accompanying this greater consumption of feeds is a greater production of milk and fat, but, as later analysis brings out, it is not a proportionately greater production. Hence, from the standpoint of the efficiency of production, or the relative amount of product returned per unit of nutrients consumed, the bean period is shown to be consistently more efficient in all departments. Reduced to a percentage basis the bean period is 9.5% more efficient in total production than the meal period, even tho there is a greater total production in the latter period.

The final conclusion that may be drawn from this experiment is that ground soybeans are more efficient for milk and fat production by the dairy cow to the extent of 9.5%, and that when soybeans are valued at $57 a ton, soybean oilmeal has a feeding value of $50 - $51 a ton.

CONCLUSIONS

1. Ground soybeans are an efficient, palatable, home-grown protein supplement for milk and fat production.
2. There was an increase in live weight to the extent of 8.1% when soybean oilmeal was fed in the ration over that when ground soybeans were fed.
3. There was 12.9% more total digestible nutrients consumed in the oilmeal period than in the soybean period.
4. Excepting the N.E. the coefficients of digestion were consistently higher when the oilmeal was fed. The N.E. was 6.3% more digestible in the bean period than in the meal period.
5. There was 13.5% greater total production of milk and 12.1% greater total production of fat in the meal period, however, the percent test was 1.69% higher in the bean period.
6. When ground soybeans are fed in the ration, there is 9.5% greater efficiency in milk and fat production than when soybean oilmeal is fed.
7. When soybeans are valued at $57 a ton, soybean oilmeal has a feeding value of $50 - $51 a ton.

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